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COLLAPSE OF BUILDINGS IN NIGERIA – ROLES OF REINFORCEMENT

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ABSTRACT
This study examined the roles of reinforcement in the Collapse of buildings in Nigeria. The study was carried out by means of interview administered to steel benders and observation of steel work on construction sites of private building owners in Ondo State of Nigeria. Information from the forty-eight building projects ranging from one storey to two storeys formed the data, on which the study is based. The study showed that: in columns, 60.4% of building projects utilized (less than or equals to 11.5mm diameter) inadequate size of reinforcement rods; in beams/lintels 75% of projects utilized (less than or equals to 11.5mm) inadequate size of reinforcement rods; in upper floor slab 64.6% of projects utilized (less than or equals to 11.5mm) adequate size of reinforcement rods. The result also showed that: in columns 64.6% of the projects used (3 No reinforcement rods instead of 4) inadequate number of reinforcement rods, in beams/lintel 75% of projects utilized (3 No reinforcement rods instead of 4) inadequate number reinforcement rods. In upper floor slab 75% of projects studied utilized (100mm-150mm centres to centres) adequate centre to centre arrangement. At the openings (doors windows) 50% of projects studied utilized (less than 300mm as projection on both sides) inadequate projection at both sides of opening. It is recommended that clients especially prospective private building owners employ structural Engineers to take care of the structural aspects of their building projects.

KEYWORDS: Reinforcement rods, Columns, beams/lintel, Structural Engineers, building projects, Nigeria

INTRODUCTION
According to Seeley (1995) concrete is strong in compression but weak in tension, and where tension occurs it is usual to introduce steel bars to provide the tensile strength which the concrete lacks. For example with a concrete beam or lintel, compression occurs at the top and tension at the bottom, so the reinforcement is placed about 25mm up from the bottom of the beam and the ends are often hooked to provide a grip. The 25mm cover prevents rusting of the reinforcement.

According to Barry (1999) the steel reinforcing bars are cast into underside of the floor with 20mm concrete cover below them to prevent the steel rusting and to give it one hour protection in case of fire. The thicker the concrete cover to reinforcement the greater the resistance of the floor to fire.

Seeley (1995) recommends the steel must be free from loose mill scale, loose rust, grease, oil, paint, mud and other deleterious substances which impair the bond between the steel and concrete. Seeley (1995) also observes that the most common form of reinforcement is mild steel bar to BS4449 or BS4482. Medium and high tensile bars are also available and deformed bars which are twisted and/or ribbed provide a better bond and greater frictional resistance than round bars and obviate the need for hooked ends.

According to Barry (1999) when the engineer designs a reinforced concrete floor he usually calculates the amount of steel reinforcement required for an imaginary 300mm wide spanning between walls as though the floor were made of 300mm wide concrete beams placed side by side.

The engineer will first calculate the combined super imposed and dead load that the floor has to support. The super imposed load is determined just as it is for timber floors and the dead load will include the actual weight of the concrete, the floor finish and the plaster of the soffit from the loads and the span the required thickness of concrete will be determined and then the cross sectional area of steel reinforcement for every 300mm width of floor calculated. According to Barry (1999) a rough method of determining the thickness of concrete required for floors of houses and flat is to allow 15mm thickness of concrete for every 300mm of span. The main reinforcement consists usually of 12mm diameter mild steel rods spaced from 150mm – 225mm apart and these span across the floor between walls supporting the floor. The 6mm diameter mild steel rods wired across the main reinforcement are spaced 450mm – 900mm apart and are called distribution rods or bars. These rods are

Table 1: Size of Reinforcement Rods (mm Ø)

S/No	1	2	3	4	5	6	7	8	9	10	11	12
Columns	10	12	11.5	11.5	12	11.5	10	10	10	12	11.5	11.5
Beams/lintel	10	10	10	12	11.5	12	10	10	12	10	10	10
Upper floor slab	12	16	12	16	14	14	14	12	11.5	11.5	10	10

S/No	13	14	15	16	17	18	19	20	21	22	23	24
Columns	12	11.5	11.5	11.5	14	11.5	10	10	12	11.5	10	11.5
Beams/lintel	12	11.5	11.5	12	11.5	10	10	10	10	10	12	12
Upper floor slab	12	16	12	16	14	14	14	12	11.5	11.5	10	10

S/No	25	26	27	28	29	30	31	32	33	34	35	36
Columns	11.5	11.5	14	10	11.5	12	11.5	10	12	11.5	10	11.5
Beams/lintel	11.5	12	11.5	10	12	10	10	12	11.5	14	10	16
Upper floor slab	11.5	10	10	11.5	11.5	12	11.5	14	16	10	11.5	11.5

S/No	37	38	39	40	41	42	43	44	45	46	47	48
Columns	10	11.5	12	11.5	14	10	11.5	10	11.5	10	10	11.5
Beams/lintel	11.5	11.5	10	10	11.5	11.5	11.5	11.5	10	10	10	10
Upper floor slab	11.5	10	11.5	16	14	11.5	11.5	12	12	11.5	11.5	11.5

Table 2: Number of Reinforcement Rods (No)

S/No	1	2	3	4	5	6	7	8	9	10	11	12
Columns	3	4	3	4	3	4	3	4	3	3	3	3
Beams/lintel	4	3	3	3	3	4	4	3	4	3	3	3

S/No	13	14	15	16	17	18	19	20	21	22	23	24
Columns	3	4	3	3	3	4	3	4	3	3	4	3
Beams/lintel	3	4	3	4	3	3	4	3	3	3	3	4

S/No	25	26	27	28	29	30	31	32	33	34	35	36
Columns	4	3	4	3	3	3	4	3	3	3	3	4
Beams/lintel	3	3	4	3	3	4	3	3	3	3	3	4

S/No	37	38	39	40	41	42	43	44	45	46	47	48
Columns	4	3	4	3	4	3	3	3	4	3	4	3
Beams/lintel	3	3	3	4	3	3	3	3	3	3	3	3

tied to the main reinforcement with wire and keep the main reinforcing rods come with spaced whilst the concrete is being placed and their main purpose is to assist in distributing point loads on the floor uniformly over the mass of the concrete. In raft foundation, according to Seeley (1995) reinforcement may take the form of steel fabric to BS4483 and this consists of a grid of small diameter bars, closely spaced and welded at the joints.

Background to the Problem

It was reported by Punch Newspaper (27th March 2008) that a building collapsed in Western Norweiglan Coastal town of Alesund in Norway on Wednesday 25th March, 2008 where 5 people died.

A report from Nigerian Tribune Newspaper (19th February, 2008) indicated that a 3-storey structure collapsed at No 10 Oke Popo Street Lagos Island in Lagos State Nigeria, where 12 people died, it also affected 2 other adjoing buildings that are to be pulled down.

Reported by Nigerian Tribune Newspaper (July 30th 2008) was the collapse of a-storey shopping plaza, situated at Utako district of Abuja on 29th July 2008.

Table 3: Centre to Centre Placement of Reinforcement Rods (mm)

S/No	1	2	3	4	5	6	7	8	9	10	11	12
Upper floor slab	300	100	100	300	150	300	100	100	100	100	100	100
S/No	13	14	15	16	17	18	19	20	21	22	23	24
Upper floor slab	100	100	100	350	75	100	75	100	100	100	100	150
S/No	25	26	27	28	29	30	31	32	33	34	35	36
Upper floor slab	100	300	100	100	300	100	100	300	125	400	125	125
S/No	37	38	39	40	41	42	43	44	45	46	47	48
Upper floor slab	100	300	125	300	125	400	100	300	125	100	100	100

Table 4: Length of Projection of Reinforcement Rods at the Openings (mm)

S/No	1	2	3	4	5	6	7	8	9	10	11	12
Openings	150	400	150	150	450	150	300	300	150	150	450	*150*
S/No	13	14	15	16	17	18	19	20	21	22	23	24
Openings	400	150	400	150	150	150	100	400	150	450	300	300
S/No	25	26	27	28	29	30	31	32	33	34	35	36
Openings	100	150	300	150	300	150	300	150	300	300	300	300
S/No	37	38	39	40	41	42	43	44	45	46	47	48
Openings	400	150	450	150	450	150	150	450	300	300	150	150

Collapsed also, was a four-storey building at Idi Araba, Lagos State as reported by Nigeria Tribune Newspaper (March 27th 2009.

It was reported also in The Nations Newspaper (May 7th 2009) that a yet to be completed 3-storey church building collapsed at Ochi Street, Achara Layout in Enugu, in Nigeria.

Fadamiro (2002) reported some incidences of building collapse which were as a result of failure of structural members: uncompleted 2-storey building at the premises of St. Thomas Anglican Church, Isikan Akure on September 30th 1988 where 2 persons were reported dead and many others injured; school building at Diobu Port Harcourt in April 1990 where over 50 people were reported dead; residential building at Idusagbe lane, Idumota Lagos on September 14th 1987, where 4 people died and 15 injured; 2-storey building under construction at

Agege, Lagos on May 9th 1987 where 17 people died and 12 injured; Mosque building at Osogbo in May 1986, no death was reported; uncompleted 4-storey building at Iponri Lagos on May 20th 1985 where 13 people died; 3

Findings
Table 5: Summary of Findings

REINFORCEMENT		QUALITY	
		Adequate (%)	Inadequate (%)
Size (mm Ø)	in columns in Beams/lintel in Upper floor slab	39.6 (11) 25 (12 64.6 (21)	60.4 (29) 75 (36) 35.4 (17)
Number (No)	in Columns in Beams/lintel	35.4 (17) 25 (12)	64.6 (31) 75 (36)
Centres to centres	in Upper floor slab	75 (36	25 (12)
Projection	at Openings	50 (24)	50 (24)

residential buildings at Barnawa Housing Estate Kaduna in July 1980 where 6 people died; and a multi storey building at Mokola Ibadan in October 1974 where 27 people were reported dead.

This study is therefore set out to determine the roles of reinforcement in structural failures in building projects and proffer solutions to them. This will curb the incidences of losses of lives and properties.

The objectives of the study are to:

- Determine the sizes in *mm* diameter of reinforcement rods in columns, beam/lintel and upper floor slab on construction sites.
- Determine the number of reinforcement rods placed in columns and beam/lintel on construction sites.
- Determine the centre to centre placement of reinforcement rods in upper floor slab on construction sites.
- Determine the *mm* projection reinforcement rods at both sides of openings.

METHODOLOGY

The study was carried out by means of interview of steel benders and observation of steel work on construction sites. Because of the constraints of time and fund the study is limited to Ondo State of Nigeria. Information from 48 building projects by private building owners formed the data used in the study.

The interview and observation the means of eliciting information will help to determine the size of reinforcement rods that where utilized in columns, beams/lintel and upper floor slab; number of reinforcement rods placed in columns and beams; centre to centre placement of reinforcement rods in upper floor slab and length of projection of reinforcement rods at both sides of the openings. The data will be analyzed by percentages.

From Table 1
In Columns: less than or equals to 11.5mm Ø reinforcement rods were utilized on 60.4% (29) of building projects studied (inadequate size) while 12mm Ø or greater than were utilized on 39.6% (11) of projects (adequate size).

In beams/lintel: less than or equals to 11.5mm Ø reinforcement rods were utilized on 75% (36) of building projects studied (inadequate size) while 25% (12) of projects utilized 12mm or greater than reinforcement rods (adequate size). In the upper floor slab: less than or equals to 11.5mm Ø reinforcement rods were utilized on 35.4% (17) of projects studied (inadequate size) while 64.6% (21) of the projects used greater than or equals to 12mm Ø reinforcement rods (adequate size).

From Table 2:
In Columns: 64.6% (31) of the projects utilized 3 No reinforcement rods instead of 4 (inadequate number) while 35.4% (17) utilized 4 No reinforcement rods (adequate number)

In beam/lintel: 75% (36) of the projects utilized 3 No reinforcement rods instead of 4 (inadequate number) while 25% (12) projects utilized the normal 4 No reinforcement rods (adequate number)

From Table 3
In the upper floor slab: 75% (36) of the projects utilized 100mm-150mm centre to centre (adequate) while 25% (12) utilized above 150mm centre to centre (inadequate).

From Table 4
At Openings (doors windows): 50% (24) of projects utilized less than 300mm as projection at both ends (inadequate projection) while 50% (24) utilized 300mm and above as projection at both ends of openings (adequate projection).

DISCUSSION
The findings from the study which showed inadequacies in the size of reinforcement rods utilized in Columns and beams/lintel; inadequacies in the number of rods utilized in columns and beams/lintel; and also inadequacies in the projection of rods at openings. They are all in agreement with Sebotie (1996) who discovered in Lagos State that inadequate reinforcement in numbers such as slabs, columns, beams etc. are one of the reasons of building collapse. The findings are also in conformity with the allegation of Makinde (1996) that sub-standard building materials such as reinforcement rods have flooded the market. They are also in consonance with the qualitative assertion of Odunlami (2002) that various reinforcing rods come to site with varying diameters and strength.

RECOMMENDATION
It is hereby recommended that prospective private developers employ the services of Structural Engineers who will supervise the structural works in the building project and ensure that the steel benders utilize appropriate size, number and length of reinforcement rods on building projects in Nigeria.

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